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May 4, 2018

Mr. James Reilly, Director
U.S. Geological Survey
12201 Sunrise Valley Drive, Mail Stop 100
Reston, VA 20192

Dear Director Reilly,

The Scientific Earthquake Studies Advisory Committee (SESAC) was appointed and charged, through Public Law 106-503 re-authorizing NEHRP, to review the USGS Earthquake Hazard Program's roles, goals, and objectives; assess its capabilities and research needs; and provide guidance on achieving major objectives and the establishment of performance goals. SESAC held meetings on October 10-11, 2017, and March 5-6, 2018, in its continuing efforts to fulfill its mandate for the USGS Earthquake Hazards Program and Congress.

A healthy, robust US Geological Survey Earthquake Hazards Program is essential because the USGS must be able to deliver trusted and authoritative information on earthquakes, some of which are going to be damaging to life, property and the economy.

I have attached a report that summarizes the SESAC discussions from these two meetings. If clarification is needed on any issue or you would like a fuller description of any issue, please do not hesitate to contact me.

With warm regards,

A handwritten signature in black ink, reading 'Ralph J. Archuleta'.

Ralph J. Archuleta, Chair of SESAC (through March 2018).
Research Professor and Emeritus Professor

cc: David Applegate, Associate Director, Natural Hazards
William Leith, Program Coordinator, Earthquake Hazards Program
Members, Scientific Earthquake Studies Advisory Committee

SESAC Report 2017-2018

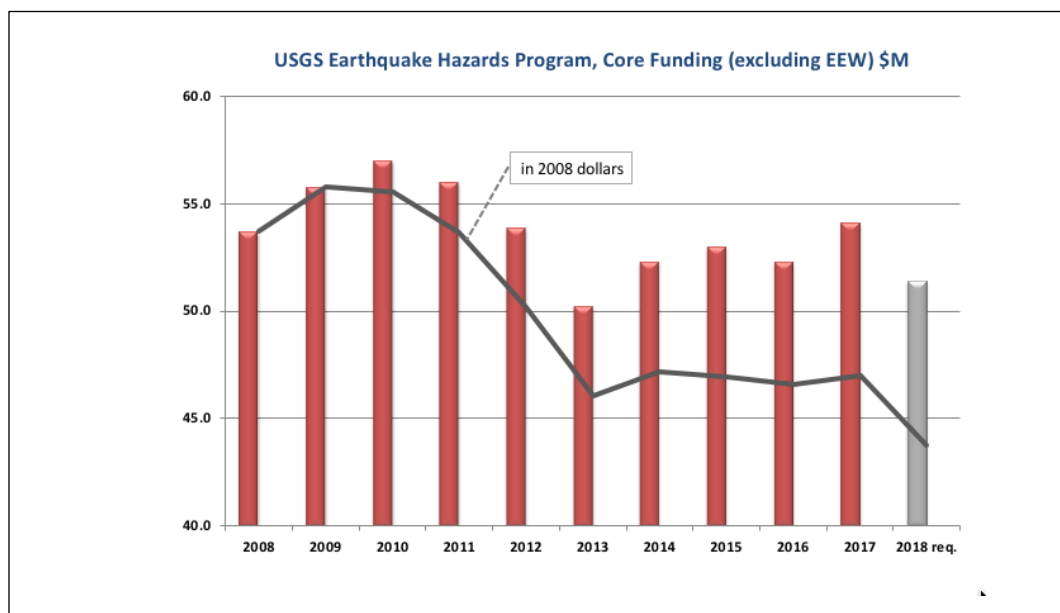
Members present for the Scientific Earthquake Studies Advisory Committee (SESAC), March 2018: Ralph Archuleta (Chair), Greg Beroza (Advanced National Seismic System (ANSS) Chair), Roland Burgmann (National Earthquake Prediction Evaluation Council (NEPEC) Chair), Goran Ekstrom, Julie Furr, Maureen Long, Janiele Maffei, Tim Melbourne, (Robert Pekelnicky, by phone)

Members not present: John Anderson (National Seismic Hazard Maps (NSHM) Steering Committee Chair)

USGS Participants, March 2018: Bill Leith (Earthquake Hazards Program (EHP) Coordinator), Mike Blanpied (EHP Associate Coordinator), Steve Hickman (Earthquake Science Center Director), Jill McCarthy (Geologic Hazards Science Center Director), Cecily Wolfe (ANSS Coordinator), plus many others who gave presentations (see agenda, Appendix B).

The SESAC met on March 5, 6, 2018 on the Caltech campus in Pasadena, California. The SESAC also met on October 10-11, 2017, in Golden, Colorado. A summary of that meeting is Appendix A. The agendas for both October 2107 and March 2018 are shown as Appendix B. This report is a combination of the issues discussed at these two meetings. Appendix C is the listing of SESAC members and their affiliations.

The USGS Earthquake Hazards Program (EHP) has continued its exemplary performance in monitoring earthquakes and mitigating the effects of earthquakes for this nation, but it is at a tipping point between available resources and demands placed on the program. One area that has grown with an increase in funding is ShakeAlert, also known as earthquake early warning (EEW). This product is rooted in the EHP's commitment to a dense, modern seismic network. EEW does not and cannot exist without the cadre of scientists and technicians who provide the intellectual and technological framework. However, with steadily diminishing funding for the past decade, the core of the EHP—the body of its scientists and technical personnel—is eroding. The balance between monitoring and research is fragile. With future expectations to continue to expand programs such as EEW, that balance is unsustainable without a commitment from the Director of the USGS, the Department of Interior, and Congress.



A healthy, robust US Geological Survey Earthquake Hazards Program is essential because the USGS must be able to deliver trusted and authoritative information on earthquakes, some of which are going to be damaging to life, property and the economy.

Issues:

1. Our primary concern is the ongoing and serious diminution of the scientific core of the EHP. The EHP is the primary organization in the US dedicated to monitoring earthquakes and mitigating their hazards. This diminution has been consistently presented to the SESAC for several years.
 - a) The scientific base is eroding through continued flat funding. This base underpins the EHP products such as ShakeAlert, national seismic hazard maps, PAGER (Prompt Assessment of Global Earthquake Response) and other essential products.
 - b) Retirements, without replacement, are reducing the available expertise within the EHP in all areas, e.g., strong ground motion, seismic hazard maps, geodesy, CEUS hazard assessment, induced seismicity. Although the Mendenhall postdoctoral research program has been of real value in attracting and evaluating exceptional early career scientists who might fill part of the void, without funding to permanently hire the identified candidates their skill and knowledge are lost to the EHP.
 - c) The EHP juggles existing resources in order to meet current obligations, often passing on new initiatives in order to preserve ongoing programs. Without a vibrant and sufficient cadre of scientists and technical staff, the EHP will be unable to fulfill those obligations to the nation, much less take on new initiatives that will mitigate earthquake hazards. We emphasize that there will be new directions in which EHP should play a leading role, but it will be unable to do so due to lack of qualified personnel. This will be to the detriment of the nation in its preparation for earthquakes.
2. SESAC reaffirms its principle that monitoring should not consume more than 50% of the EHP budget. The momentum of ShakeAlert (EEW) presents a challenge now and will present an even greater challenge in the future. Earthquake early warning resonates with the public and Congress. It exists as a product of the modernization of the ANSS plus regional networks. It will require more resources as EEW continues to expand. Implementation for a similar system elsewhere in the US would be impossible to meet with current funding levels. It is easy to forget/ignore that products like EEW are founded on solid, basic science into the nature of earthquakes. This fundamental understanding of earthquake science comes from highly-trained people dedicated to their work, not from instruments and technology. There is a diverse body of research (seismology, geology, geodesy, laboratory) that must be integrated to understand the nature of earthquakes and quantify the available data in order to deliver successful products. The success of the EHP has been its ability to merge monitoring and research. As earthquake monitoring grows, earthquake hazard assessment and earthquake research must grow in equal measure.
3. The EHP has successfully found support for the operation and maintenance of the adopted stations from the NSF Transportable Array in the central and eastern US (CEUS). These stations are now in a network, N4, that will be maintained by the USGS EHP Albuquerque Seismic Lab and will aid immensely in the understanding of earthquake hazards in the CEUS. With relief funds for Hurricane Maria, the Puerto Rico seismic network will be rebuilt taking advantage of modern sensors and technology. The SESAC applauds the EHP's achievement of these critical objectives.
4. SESAC reaffirms its recommendation that EHP not implement the plan recommended by the Alaskan Earthquake Monitoring Working Group (AEMWG) using current program

resources. The necessary financial resources grossly exceed available funds in the EHP budget. Besides the capital expense, the annual operating cost would be about 2/3 of the entire annual expenditure for regional networks everywhere else in the US—pop. 321,000,000 vs 700,000 in Alaska. The AEMWG acknowledged that it did not consider the financial impact on the EHP. Even in a limited implementation of the recommendation, the EHP will be pushed to cut existing programs to mitigate the long-term fiscal effects of the AEMWG plan on the EHP budget (excluding EEW) if the EHP continues with flat funding. Earthquake monitoring in Alaska must not grow at the expense of the core program (Issues 1 and 2).

5. SESAC has endorsed Operational Aftershock Forecasting (OAF), i.e., determining the probabilities of the number and magnitude of earthquakes following an earthquake with $M \geq 5.0$ including their associated spatial and temporal extent. Extending this method to a proposed 24/7 Operational Earthquake Forecasting (OEF), i.e., continuously determining and updating probabilities that an earthquake might occur independent of the occurrence of an earthquake with a particular magnitude, is a much lower priority and is currently not endorsed by the SESAC given the current EHP budget.
6. SESAC commends the EHP for its advances and ability to adapt on multiple fronts, e.g., EEW, induced seismicity, urban hazard maps, operational aftershock forecasting, CEUS hazards, subduction zone hazards to name a few. The USGS Circular 1429 (Advanced National Seismic System, Current Status, Development Opportunities and Priorities for 2017-2027) lays the ground work for the next decade of monitoring. Implementation of all these activities requires a budget (Table A1, Circular 1429) more than twice the current budget. SESAC reaffirms its belief and recommendation that the budget for the EHP should be in line with the findings of the National Research Council¹ that documents a need for nearly quadrupling the EHP budget if the EHP is to fulfill the expectations of the nation.

¹ National Earthquake Resilience: Research, Implementation and Outreach, The National Academies Press, ISBN 978-0-309-18677-3, 244 pp (2011).

Appendix A

Minutes: Scientific Earthquake Studies Advisory Committee Meeting October 10-11, 2017 Golden, Colorado

Federal Register Notice: <https://www.gpo.gov/fdsys/granule/FR-2017-09-26/2017-20546>

Meeting Agenda and Presentations: [link](#)

Read-ahead materials and presentations are available upon request or by FTP at:
<ftp://ftpext.usgs.gov/pub/er/va/reston/EHP/SESAC>

Members present: Greg Beroza (acting Chair and ANSS Steering Committee Chair), Roland Burgmann (NEPEC Chair), Goran Ekstrom, Maureen Long, Janiele Maffei, Tim Melborne, Bob Pekelnicky.

Members not present: Ralph Archuleta (chair), John Anderson (NSHM Steering Committee Chair), Julie Furr.

USGS Participants: Bill Leith (EHP Coordinator), Cecily Wolfe (ANSS Coordinator), Mike Blanpied (EHP Associate Coordinator), Jill McCarthy (Geologic Hazards Science Center Director), Steve Hickman (Earthquake Science Center Director), Mark Petersen (NSHM Project Chief), Nico Luco (Engineering Risk Project Chief); Peter Haeussler (EHP Alaska Region Coordinator), Brian Sherrod (EHP Pacific Northwest Region Coordinator), Keith Knudsen (Earthquake Science Center Deputy Director), Linda Pratt (Geologic Hazards Science Center Deputy Director).

Guests: There were no members of the public present at any point during the meeting, and no written questions or comments were submitted before, during or after the meeting.

General: The Scientific Earthquake Studies Advisory Committee Meeting (SESAC) met for a program update. Because the Committee Chairman, Dr. Ralph Archuleta, was unable to attend, the Earthquake Hazards Program (EHP) did not make any specific requests of the committee and indicated it does not require a formal report from the meeting. The meeting was led by Dr. Greg Beroza, who serves as Chair of a SESAC subcommittee, the ANSS Steering Committee. Pre-meeting materials were distributed electronically via the FTP site, above. Committee members were previously briefed on committee ethics rules and practices by USGS Ethics Councilor Nancy Baumgartner (most on May 11, 2017).

Dr. Bill Leith, USGS EHP Coordinator, began the meeting by reviewing the meeting agenda and providing a brief program overview. He emphasized that, except for the new funding for earthquake early warning, the budget of the EHP has not kept up with inflation since 2010. This has resulted in the program ending funding to several of the ANSS regional seismic networks, reducing the number of research grants given, and the EHP-funded centers slowly losing scientific staff as retirements cannot be replaced. Leith expects that this contraction of program-funded activities will continue in the current budget climate.

The remaining hours of the morning were focused on matters to do with the Advanced National Seismic System (ANSS), including the Central and Eastern U.S. Seismic Network (also known as the “N4 network”), the NSF Transportable Array in Alaska, “ShakeAlert” Earthquake Early Warning

Implementation, and damage to the Puerto Rico Seismic Network as a result of hurricane Maria. These topics were led by Cecily Wolfe and Greg Beroza. Beroza indicated that the state-of-health of the ANSS Regional Networks has risen to a top priority for the ANSS Steering Committee. Ekstrom asked, what is the “backup plan” for the regional networks? The NEIC has this responsibility, and McCarthy replied that the NEIC is constantly improving its ability to monitor regional earthquakes in the U.S. As in the past, the SESAC also expressed support for the USGS efforts to retain the N4 as a high-quality network and for the USGS.

Leith began the afternoon session by reviewing the EHP budget situation, state of health and recent external guidance, including from the SESAC. Question and discussion included:

--What is the status of the NSF NGE0 competition? A: the National Science Board is to meet in Nov. 2017.

--for the PRSN, is generator fuel to last months? What is the implication for a major U.S. earthquake? (no answer)

--for EEW, what distinguishes class A and class B stations? A: Class A have both BB and SM sensors; class B have just SM sensors.

--Melbourne asked about the testing of mass alerting (for EEW). A: this is being done in “pilots”, including one with the City of L.A that might result in alerts to the public if testing with city employees is successful.

--it was noted that in the recent Mexico earthquakes, the public is tolerant of false alerts in their EEW system, which also increased earthquake preparedness in general. “SkyAlert (private EEW) [subscriptions increased](#) after the earthquake.

--for EEW, the State contracted a cost estimate for state-wide implementation.

This was followed by state-of-health updates from the Science Center Directors, McCarthy and Hickman. McCarthy projects a \$600k-\$700k shortfall in core funding in FY18 (excluding future non-USGS funding); will not be able to ‘backfill’ upcoming retirements. Hickman noted several recent hires and searches underway (enabled by recent retirements and ShakeAlert development funding), and expects the move from Menlo Park to NASA Ames in Nov-Dec 2018.

The afternoon focus topics were the National Seismic Hazard Model and Aftershock Forecasting. Mark Petersen reviewed the recent deliberations and recommendations of the National Seismic Hazard Model (NSHM) Steering Committee (the Chair of that subcommittee, John Anderson, not being present). The next push is the 2018-2020 model updates.

The design tool used by engineers will be removed from the EHP web site with an upcoming end to Oracle support; USGS is shifting its emphasis to providing seismic design values via web services. These web services can either be accessed directly from USGS or through user interfaces supported by ATC and ASCE. ATC will provide USGS with model-derived info free of charge, supported by ads (and FEMA core support). ASCE plans on charging users an annual fee of approximately \$50/year. It was noted that the ACEHR disagreed with this approach; the issue was the USGS getting credit. Also, the ASCE-provided report will not be “customized” as the USGS one is now. SESAC supported the USGS plan of focusing on making its data available (i.e., through web services) and de-emphasizing support of a customized report. Luco noted that demand was at times 1,800 inquiries per day, and that the past focus has been on buildings (vs. bridges and other structures).

Petersen noted that the 2017 one-year forecast model (“induced seismicity map”) does not use a new ground motion model. Burgmann stated the need to sustain the seismicity-based model. Peckelnicky

commented on mitigating non-structural hazards. On the topics of Operational Earthquake Forecasting and a possible “UCERF4”, Beroza remarked that the USGS can’t afford to have an information vacuum after a large earthquake. Peckelnicky commented that basin effects affect 5-story buildings.

Petersen noted that the Alaska seismic hazard model is >10 years old, and Hawaii >20 years. The Hawaii map update has recently been prioritized by the NSHM SC. For Alaska, the project is still waiting on a new ground motion model, NGA-subduction, now expected in 2019. These topics were followed by a short discussion on a “funding model” for NSHM partnerships.

Blanpied provided a status update on EHP activities in Aftershock Forecasting and Operational Earthquake Forecasting (OEF). The EHP is developing a new earthquake-linked product, and operational aftershock forecast, which is partially completed. Hickman noted that for OEF, enough resources are needed to “do this right”, including dedicated computer programming support, and that the ESC is developing a business plan for an automatic OAF system in the U.S. McCarthy remarked on the “opportunity cost” of OEF and asked whether the public is ready for it. She asked about the insurance component, whether expected losses could be reported (the “spatial component”) and Blanpied replied that it’s “on the horizon”. Blanpied also talked about the CREW earthquake risk communication report.

The first day ended with an open discussion among committee members.

The second day began with Leith presenting the new USGS Subduction Zone Science Plan (USGS Circular 1429). A question arose about “outreach” to the parallel, community driven SZ4D planning efforts. Is there ambivalence in that community regarding the importance of a hazard (vs. research) focus? Missing in SZ4D planning is a risk assessment piece (i.e., a quantification of the vulnerabilities), which USGS engagement would facilitate.

This was followed by two focus talks, one by Brian Sherrod on Ongoing and Planned Activities in Cascadia, and one by Peter Haeussler on Ongoing and Planned Activities in Alaska.

In his review of Cascadia great earthquake recurrence, Sherrod noted that this is a large, new project initiated in 2017 with 30 core people and 50 contributing. They will be collecting offshore seismic and bathymetry in FY18 and FY19, as well as LiDaR for land areas. Sherrod remarked on a workshop and talk two weeks prior, with Chris Goldfinger, who has studied the offshore turbidites, and that Chris is working with the USGS group. Sherrod noted that the USGS does not have a full-time micropaleontologist, and that to get this crucial expertise externally is expensive and time-consuming.

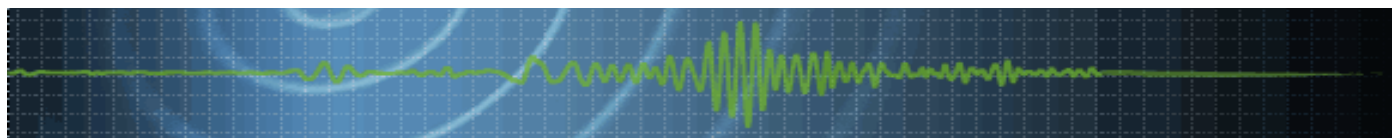
One surprising finding (or gap) is that no landslides have been found that were clearly triggered by the 1700 M9 earthquake. A second new and striking finding is that evidence of a 4m tsunami run-up has been found near Tacoma, in Puget Sound. This was modeled using GeoCLAW to have a 6-hour tsunami travel time.

For Alaska research, Haeussler emphasized that the highest priority for USGS is characterizing plate boundary faults for earthquake and tsunami hazard—these dominate seismic hazard maps. Improving understanding of these faults is of greatest interest for understanding earthquake processes for the US and globally and provides the largest impact and greatest applicability. Collaborations are vital for leveraging funds and expertise, and with those collaborations, current staff (4 persons) and operating expenses are sufficient to make progress within the current scope of project. However, at current scope, decades of work will be required to decipher Alaskan megathrust paleoseismology.

The second half of the morning was a review of the EHP's strategic planning efforts, including many of the strategic planning efforts now underway in the USGS.

After lunch, committee members engaged in an open discussion of the topics discussed in the meeting (a so-called Executive Session). Concern was expressed by several members about the significantly outdated seismic hazard map for Alaska, who asked if we can make the case that an update of this map is time-critical. For instance, the ground motion terms for SZ earthquakes may be vintage 1977. Peckelnicky mentioned that engineers don't want "a moving target" for building design, and also that codes can be updated out-of-cycle.

Appendix B



Scientific Earthquake Studies Advisory Committee

vers. 2/27/2018

Avery House, 370 Holliston Ave, CalTech Campus, Pasadena, CA

March 5-6, 2018

dial-in: 855-547-8255; code: 482 456 47

read-aheads: <ftp://ftpext.usgs.gov/pub/er/va/reston/EHP/SESAC>

use 'guest' login

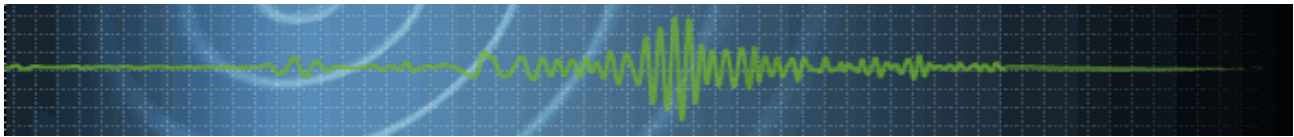
AGENDA (all times Pacific Time)

Monday March 5th

8:15	gather in Hotel lobby for ride-share to Avery Library (or 1.3 mile walk)	
8:45	meet and greet	
9:00	Introductions	Archuleta & Committee
9:10	FY18 Program Overview and FY19 Budget Proposal	Leith
10:00	Science Center Updates	McCarthy, Hickman
10:20	Break	
10:40	ANSS updates (PRSN, CEUSN, Alaska TA, other topics)	Wolfe
11:20	Ethics Briefing	Baumgartner
11:50	Lunch	
1:00	Earthquake Early Warning - 2018 Overview for SESAC and EWG	Given
	Earthquake Early Warning - Product and Alert Generation	EEW project members
	Earthquake Early Warning - Alert Delivery	EEW project members
3:00	Break	
3:15	Earthquake Early Warning - Communication, Education and Outreach	DeGroot
	Earthquake Early Warning - Project Management	Given
5:00	discussion	Committee
5:30	Adjourn	
6:30	Group Dinner - Il Fornaio (24 W. Union St., Pasadena)	all

Tuesday March 6th

8:45	meet and greet	
9:00	NEPEC Report, Operational Earthquake Forecasting, OAF Product	Burgmann and Blanpied
9:30	HayWired Scenario and Rollout	Hudnut
10:00	Subduction Zone Science Planning	
10:15	Break	
10:30	EHP vision, strategic planning, science priorities, deprioritizations	Leith
12:00	Lunch	
1:00	Committee Deliberations	Committee
2:00	adjourn	



Scientific Earthquake Studies Advisory Committee

10/5/17

The Golden Hotel, Golden, Colorado

October 10-11th, 2017

dial-in: 855-547-8255; code: 482 456 47

read-aheads: <ftp://ftpext.usgs.gov/pub/er/va/reston/EHP/SESAC>

use 'guest' login

AGENDA (all times Mountain Daylight Time)

Tuesday October 10th

8:45	meet and greet	
9:00	Introductions	Beroza and Committee
9:10	Program Overview	Leith
9:30	ANSS: Steering Committee Review, Regional Network Health	Beroza and Wolfe
10:30	Break	
10:45	ANSS: Hot topics — CEUSN, Alaska TA, PRSN	Beroza and Wolfe
11:15	ANSS: Earthquake Early Warning Implementation	Wolfe and Leith
11:45	ANSS: Discussion	Committee
12:00	Lunch	
1:00	Program Budget Matters, State-of-Health and External Guidance	Leith
1:30	Science Center Updates	McCarthy, Hickman
2:15	National Seismic Hazard Model Steering Committee report and related	Petersen (for Anderson)
3:15	Break	
3:30	Aftershock Forecasting and OEF	Blanpied
4:00	discussion	Committee
5:00	Adjourn	
6:00	Group Dinner	

Wednesday October 11th

8:45	meet and greet	
9:00	Subduction Zone Science Plan	Leith
9:15	Ongoing and Planned Activities in Cascadia	Sherrod
9:45	Ongoing and Planned Activities in Alaska	Haeussler
10:15	Discussion	Committee
10:30	Break	
10:45	EHP Strategic Planning Efforts	Leith
11:30	Discussion	Committee
12:00	Lunch	
1:00	Committee Deliberations	Committee
2:00	adjourn	

Appendix C

SESAC members

Ralph Archuleta	Chair, SESAC	Research Professor and Professor Emeritus, Earth Science, University of California, Santa Barbara, CA
John Anderson	Chair, National Seismic Hazard Map Committee	Professor, Seismology, University of Nevada, Reno, NV
Greg Beroza	Chair, USGS Advanced National Seismic System (ANSS)	Professor, Geophysics, Stanford University, Stanford, CA
Roland Burgmann	Chair, National Earthquake Prediction Evaluation Council (NEPEC)	Professor, Earth and Planetary Science, University of California, Berkeley, CA
Goran Ekstrom	SESAC	Professor, Earth and Environmental Sciences, Columbia University and Lamont Doherty Earth Observatory, NYC, NY
Julie Furr	SESAC	Professional Engineer, Rimkus Consulting Group, Inc., Memphis, TN
Janiele Maffei	SESAC	Professional Engineer, Chief Mitigation Officer, California Earthquake Authority, Sacramento, CA
Tim Melbourne	SESAC	Professor, Geological Sciences, Central Washington University, Ellensburg, WA
Maureen Long	SESAC	Professor, Geology and Geophysics, Yale University, New Haven, CT
Robert Pekelnicky	SESAC	Principal Engineer, Degenkolb Engineers, San Francisco, CA